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THE HARVARD PROGRAM OF GALACTIC EXPLORATIONS

By Dr. HARLOW SHAPLEY

DIRECTOR OF THE HARVARD OBSERVATORY

THE work carried on at the Harvard Observatory for the past ten years has included the systematic survey of various parts of the stellar universe. Recently we have been able to inaugurate active studies in the whole range from the nearest stars to the groups of galaxies at distances of the order of a hundred million light years. For convenience of operation and discussion the program of exploration and measurement has been divided into eight major sections, each concerned with a separate territory and employing in general a special method and equipment. Ten photographic telescopes and approximately thirty observers and investigators are involved in the program. In the following paragraphs I shall outline briefly the progress in the eight territories, of which five lie within the galactic system and three in the extragalactic universe.

(1) THE SOLAR NEIGHBORHOOD

A large majority of the stars within fifty light years of the sun are of less than solar luminosity, and most of them are below naked-eye visibility. Thus a recent compilation of those stars known to be nearer than sixteen light years shows but 40 per cent. brighter than the sixth magnitude. The exploration of the solar neighborhood is therefore a search for dwarf stars among telescopic objects.

It is important to have as complete a census as possible of the solar neighborhood—the most useful sample we have of a volume of space. A thoroughly observed frequency distribution of stellar luminosities and a knowledge of the density-in-space laws for the stars within fifty light years of the sun are fundamental in the analysis of stellar development and the structure of stellar systems.

The Harvard work on the space distribution of nearby stars is at present confined to the southern hemisphere and consists in the detection of these stars, not through parallax measures, but through their large proper motions. Photographs made with the 24-inch Bruce doublet at the southern station (now near Bloemfontein, South Africa) cover practically all the southern sky for stars to the seventeenth magnitude and about one fourth of the southern sky for stars to the eighteenth magnitude. Many of the plates were made more than thirty years ago. A comparison of these plates (scale $1' = 1$ mm) with the plates made currently on the same fields with the same telescope will provide much material on the number and on the distribution in space and in luminosity of the stars in the circumsolar region. At present approximately 40 per cent. of the telescope's working time is devoted to proper motions, and already a large number of conspicuously moving stars have been found on the Bruce plates by Dr. Luyten, who continues at the University of Minnesota the study begun at Harvard.

(2) The Region of the Brighter Stars

The great majority of naked-eye stars lie between the distance limits of fifty and five hundred light years, though some of them with unusually high intrinsic luminosities are farther away. Within the same limits of distance are probably half a million telescopic stars. Their distribution in space and the general structure of the stellar system which they compose can be determined in part from studies of proper motion and trigonometric parallax. The naked-eye stars of the region can probably be most effectively studied, however, through those methods of distance measurement that depend on knowledge of the absolute magnitudes (intrinsic luminosities) of the stars as estimated from their spectra. With the absolute magnitudes known and apparent magnitudes measured, distances are readily computed.

Our own explorations of this territory are very largely based on spectroscopic parallaxes. For several years at both the southern and the northern stations we have systematically accumulated spectrograms suitable for the work; methods of using the various classes of spectra are under study at Harvard and elsewhere and it appears probable that good criteria of absolute magnitudes will soon be available for many of the spectral classes. We can use in this survey not only the plates specially collected for the purpose but also the tens of thousands of short dispersion spectrum plates in the Harvard photographic collection. The analysis can thus go several magnitudes below the naked-eye limit, extending the territory to the distance of a thousand light years or so, and making possible a much more complete census of the dwarf stars within a few hundred light years of the sun.

(3) The Local System

We have good but not incontrovertible evidence of the existence of a localized star cloud in our part of the galaxy. Its diameter is several thousand light years, its population is in the tens or hundreds of millions of stars. I believe that this local system may be comparable in dimensions and composition with the Magellanic clouds or with a typical spiral nebula. But it will take long and laborious study to unravel the complications of stellar structure in this third territory which, we assume, extends out to a distance of approximately five thousand light years.

The Henry Draper Catalogue gives the spectra of 225,000 stars as classified by Miss Cannon, and affords material for the statistical discussion of their space distribution. Most of the stars, however, to the magnitude limit within which the catalogue is essentially complete, are not more distant than one or two thousand light years; they do not represent satisfactorily the local system.

Nearly ten years ago we began an extension of the Henry Draper Catalogue to the fainter stars, paying special attention to the rich regions in low galactic latitude. The new spectrum plates required for the work were made at the southern station, mainly with the Metcalf 10-inch camera. A hundred thousand faint spectra have now been classified for the Henry Draper Extension. The limiting photographic magnitude of completeness is approximately 11.5, corresponding to a fourfold extension in distance over the Henry Draper Catalogue. The distance limits are, of course, quite different for the various spectral classes, because of the diversity in absolute magnitude from class to class.

Scarcely one fourth of the Milky Way has been covered at the present time by the Extension, but preliminary analyses have already shown that the new work will be of much value in advancing our knowledge of that nearer part of the Galaxy which we call the Local System. An equally useful result of the program will be the determination and the publication of spectra and magnitudes of great numbers of individual faint stars, thus giving the students of positions, motions and luminosities basic data for their investigations.

For the work on spectral classification, as for the projects in several of the other territories under exploration, the measurement of the stellar magnitudes is fundamental. To provide the necessary standards of photographic brightness, the Harvard photometric program has been taken up actively again after an interruption of several years.

(4) THE MILKY WAY

The stars within five thousand light years of the sun constitute a trifling proportion of the galactic system as outlined by globular star clusters and the Milky Way clouds. The faint stars of the Milky Way are so remote that spectroscopic methods of determining their distances are as yet quite impossible, and trigonometric and proper motion measures are hopelessly inadequate. Statistical analyses, based on the counts of stars of various magnitudes, assist in discovering the structure of the nearer parts of the Milky Way; but perhaps now the most satisfactory attack on its extent and structure can be made through the study of the periods and light curves of variable stars. The methods of using eclipsing binaries, long period variables, novae, and Cepheid variables in the measurement of stellar distances are well known to the students of stellar astronomy. The Cepheid variables are especially powerful in measuring space, through the fortunate circumstance that the lengths of their periods of variation are closely correlated with their absolute magnitudes. The period-luminosity relation for Cepheid variables is the key to the measurement of practically all distances greater than a few thousand light years.

About seven years ago a program for the systematic photography of Milky Way variable stars was inaugurated at our northern and southern stations to supplement the plates of the Harvard sky patrol, which had been in operation for approximately thirty years. The regular patrol furnishes ample material for the three or four thousand variable stars brighter than the twelfth magnitude, but it contributes little for the fainter variable stars associated with the Milky Way star clouds. In the new observing program, which is carried on with the larger telescopes at Cambridge and Bloemfontein, several thousand photographs have been taken. The whole of the galactic belt is covered systematically. In three lines along the galactic circle 196 regions have been chosen, so centered that adjacent fields overlap. For purposes of comparison seventy-two variable star fields in various high galactic latitudes have also been selected for study. Particular attention is given at present to the southern Milky Way, not only because of its greater richness in variable stars and in other objects of interest, but because the northern sky is being more actively studied than the southern by other observatories.

The photographs of ten of the Milky Way fields have been examined by the workers in Cambridge, who have found nearly two thousand new variable stars and have determined the periods and light curves of several hundred. The photographs extend to the sixteenth magnitude and fainter, and many of the new variables are more than thirty thousand light years distant. The work shows conclusively that the variable stars provide an easy entry into the Milky Way star fields in which they are imbedded; but the labor of discovery and analysis is very great, and it will be ten or fifteen years before a sufficient number of the Harvard Milky Way fields are studied fully enough to outline the arrangement and dimensions of the star clouds composing the Milky Way system.

The regions so far studied are mainly in the Milky Way between Carina and Aquila. One of our first results on this program was the discovery that the dense star clouds in Sagittarius and neighboring constellations are at a distance of forty or fifty thousand light years. Apparently they form a nucleus of the Milky Way system, near the gravitational center of the surrounding system of globular star clusters. They indicate a center that agrees both in direction and in distance with the galactic center found ten years before from the study of the space distribution of individual globular clusters.

Concurrently with the systematic work on faint variable stars in the Milky Way, which is under the supervision of Miss Henrietta Swope, we have undertaken several special studies of the nearer variable stars: (a) With the help of a grant from the American Academy of Arts and Sciences an investigation of the photographic brightness of eclipsing stars has been made, providing the first extensive material available on photographic light curves of a type of variable star important to our knowledge of the shapes, surface brightnesses and mean densities of stars in binary systems, and significant therefore for theories of stellar evolution. (b) Harvard patrol plates have been used by Dr. L. V. Robinson to determine from about fifty thousand observations the photographic light curves of one hundred of the brighter Cepheid variables in an attempt to learn more of the characteristics of these stars on the basis of homogeneous material. (c) Participation by the Harvard Observatory in an international study of Cepheid variables in selected regions during the past two years has involved the measurement of sixty-two magnitude sequences, the accumulation of a thousand new photographs of the "international" Cepheids, the study of their spectra and the detailed investigation of their periods and mean photographic light curves. (d) The study of faint variables in three large fields in high galactic latitude has revealed an abundance of cluster type Cepheids and of eclipsing binaries but relatively few long period variables and no classical Cepheids, indicating the thinness of the Milky Way system.

(5) The System of Globular Clusters

The diameter of the Milky Way is not less than a hundred thousand light years; probably it is much larger. Undoubtedly the globular star clusters which are observed along the borders of the Milky Way and sparingly in high galactic latitudes extend throughout a region more than two hundred and fifty thousand light years in diameter. The galactic system may be coextensive with this system of globular clusters; and it may be that the globular clusters, with the star clouds of the Milky Way, the local system and the Magellanic clouds, form a complex system of higher order than a simple galaxy. In time we should know much about these matters. It is convenient for the present to consider that the supersystem of a hundred globular clusters constitutes the fifth stage in our explorations and marks the point where we pass from considering various parts of the galactic system to the treatment of external galaxies.

The discovery and study of variable stars in globular clusters by the late Professor Bailey at Harvard was followed by the extensive investigations of such systems with the Mount Wilson reflectors and by further photometric researches at Harvard. At the present time we know more about this territory than about any of the others. The results are summarized in a recent monograph.[1] To extend the work on these systems and on other extra-galactic objects in the southern hemisphere, a 60-inch reflecting telescope has been obtained for the station at Bloemfontein. Within a year it should add greatly to our information about the luminosity curves, variable stars, density distribution, and internal structure of globular systems, since the nearer and brighter examples of the class are too far south for analysis with northern telescopes.

Current studies of globular clusters at Harvard include a new determination of the period-luminosity relation, investigation of the small amplitude variations for stars in Messier 3 of the same luminosity and color as cluster type Cepheids, derivation of luminosity curves of the giant stars in northern clusters and the construction of contour maps of the luminosity distribution for a few of the brighter systems.

(6) The Clouds of Magellan

The present and forthcoming work on the spectra, light variations, and distribution and motions of the stars in the Magellanic clouds, and the study of their clusters and nebulae, will reflect on the problems of our local system and of the similar star clouds in the Milky Way. But as the nearest of isolated external galaxies, the clouds of Magellan should serve primarily as leads to knowledge of the millions of extra-galactic systems, for these large and complex stellar organizations in the southern sky are immediately related to spiral and spheroidal nebulae. Studies of the clouds have, in the past, included the detection of peculiar spectra, the determination of the period-luminosity relation by Miss Leavitt, the measurement by R. E. Wilson and others of the radial velocities of the included gaseous nebulae, studies of motions by Hertzsprung and Luyten, and the discovery and cataloguing of variable stars, gaseous nebulae and star clusters by various Harvard investigators.

Current Harvard work on the Magellanic clouds includes the following studies:

(a) An analysis of the number and distribution of giant and supergiant stars in the Large Magellanic Cloud, which has become possible (for the first time in any galaxy) through the establishment of standard magnitudes in the cloud.

(b) The classification of spectra of supergiant stars in the Large Cloud, including those of peculiar types with luminosities of more than ten thousand times that of the sun; Miss Cannon has classified more than three thousand of the faint spectra, most of which, however, are foreground stars in our own galaxy.

(c) The determination of the magnitudes of the brightest individual stars in one hundred and sixty open star clusters in the Large Cloud.

(d) The discovery of several hundred new variable stars in the Large Cloud, in which Miss Leavitt had previously found eight hundred; on the basis of the new discoveries, which were made on recent plates from Bloemfontein, I estimate that the total number of Cepheid variables in the Large Cloud is not less than three thousand.

(e) The determination of periods and light curves of about seventy-five Cepheid variables in the two clouds, showing that the period-luminosity relation holds for the Large Cloud as for the Small, and that the Cepheids in external galaxies are similar in amplitude of variation and in form of light curve to those in our own galactic system.

Future work on the Magellanic clouds will include an analysis of globular clusters within them, studies of the variable stars in these clusters, classification of the spectra of the highly luminous stars in the open clusters, further studies of the velocities in the line of sight—not only of the easily measured gaseous nebulae but also of the stars themselves, studies of variable stars fainter than those now attainable and the extension of the luminosity curves toward the dwarf stars for each spectral class separately. All of these researches should be carried forward rapidly with the aid of the new 60-inch reflector.

[1] Harlow Shapley, "Star Clusters," Harvard Observatory Monograph No. 2, McGraw-Hill Book Company, New York, 1930.

In the investigations of the clouds of Magellan we take full advantage of our position as external observers; future studies will still further exploit this advantage of objectivity.

(7) THE SUPERGALAXIES

The clouds of Magellan are serviceable representatives of the numerous external galaxies that lie within two or three million light years of the earth. To explore more remote regions satisfactorily we can take advantage of the tendency of external galaxies to form higher systems. These supergalaxies, or clusters of extragalactic nebulae, yield to the same type of analysis that we have used for star clusters. The use, for individual galaxies, of relative diameters and relative brightness as criteria of relative distance is unsafe, but the method can be employed with some success when mean values are obtainable for the several members of a supergalaxy.

Approximately forty clusters of galaxies are now distinctly shown on the Bruce plates at the Harvard Observatory. Their distances range from a few million to a hundred million light years. The current studies of these higher systems include the measurement of magnitudes, dimensions, positions and orientations of the individual members. The extension of the survey with long-exposure photographs to all regions of the southern sky will undoubtedly increase the number of known supergalaxies and add to our information of their distribution in space.

The most conspicuous supergalaxy under study at the present time is Coma-Virgo Cloud A, which is a stream of several hundred bright spiral, spheroidal and irregular galaxies extending over about sixty degrees of the sky. Its distance from the earth is approximately ten million light years, and its greatest length at least half as much.

(8) THE METAGALAXY

Two systematic surveys of external galaxies which are now in progress at Harvard concern the all-inclusive order which we call the metagalaxy. Of the two, the less ambitious is a catalogue of the photographic magnitudes of all external galaxies brighter than magnitude 13.0. This survey will include something less than a thousand objects. The magnitudes are based on numerous small scale photographs. The second systematic survey reaches to the eighteenth magnitude and fainter, and will probably require at least ten years for completion. It will involve the finding and the study of tens of thousands of heretofore uncatalogued objects, the measurement of their positions, approximate magnitudes and diameters, and their classification on a system peculiarly suited to the scale of the Bruce photographs.

The survey of bright objects may be assumed to extend five million light years into space, though undoubtedly many of the intrinsically fainter galaxies within that limit of distance are not recorded, and many of the high luminosity galaxies will appear in the catalogue though lying considerably more than five million light years distant. The second survey will extend to objects five magnitudes and more fainter and will reach, we may assume in a first approximation, to an average distance of fifty million light years. We are sure, however, that several of the supergalaxies found among the faintest objects are more than a hundred million light years away.

Approximately one sixth of the whole sky has been covered in the eighteenth magnitude survey. More than twenty thousand new systems have been found. For 75 per cent. of them positions have been determined and for 58 per cent. classifications have been made on the Harvard system. The number of galaxies per square degree has been counted on a large number of Bruce plates, and conspicuous deviations from uniform distribution are revealed (in addition to the well-known apparent avoidance of low galactic latitudes which is the result of obscuration by dark nebulosity). Equally distinct dissimilarities from field to field are found in the magnitude distribution, indicating that along the line of sight as well as on the surface of the sky the distribution is far from uniform. Taking the whole sky we find, in agreement with Hubble's results with the Mount Wilson reflectors, that the increase in numbers with decreasing brightness is approximately of the order of magnitude appropriate to uniform density in space, though for various large sections of the sky the uniformity criterion fails conspicuously.

As a whole, our surveys of the metagalaxy, which cover large and representative sections of the sky, give no evidence that we have measurably approached the limits of the galaxy-populated universe; we have no indication that the systems are falling off in number as we go out from our galaxy. On relativistic grounds the red shift in the spectra of distant objects can be taken as an observational indication of an expanding universe that is finite; but so far as the present census of the metagalaxy goes, the total number of galaxies and the radius of space may both be infinite.

The studies of the various territories in which our explorations proceed are closely interwoven. For instance, the luminosity curves for the solar neighbors will be of direct application in work on the integrated luminosities of the Magellanic clouds and of other external galaxies; the frequency of Cepheids in the Magellanic clouds will bear on the interpretation of

results in the Milky Way; variable star fields a comparison of the structure of the local system with that of external galaxies will eventually determine whether our galaxy is a unit organization or a supersystem; and the researches on the anatomy of bright southern globular clusters, throwing light on the nature of the faintest spheroidal galaxies, will aid in the measurement of the metagalaxy.

OBITUARY

FRANK WIGGLESWORTH CLARKE

ON May 23, 1931, Frank Wigglesworth Clarke, one of the most widely and favorably known of American chemists, quietly passed away at his home in Chevy Chase, Maryland, at the age of eighty-four years.

Dr. Clarke was born in Boston, March 19, 1847. He was the great-great-grandson of Robert Clarke, of the Scotch colony near Londonderry, Ireland, who came to this country about 1725.

Dr. Clarke's early education was obtained in schools in and near Boston, and in March, 1865, he entered the Lawrence Scientific School of Harvard University where he took up the study of chemistry under Wolcott Gibbs. Receiving the degree of Bachelor of Science in 1867, he remained at the School for another year, and published his first scientific paper, "A New Process in Mineral Analysis," in the *American Journal of Science* in 1868. In January, 1869, he went to Cornell University as assistant to Professor J. M. Crafts and, leaving that position at the close of the academic year, he returned to Boston where for the next four years he lectured on chemistry in the newly established Boston Dental College and eked out his small income by lecturing in other schools and by journalistic work.

From early boyhood he had a strong bent toward the preparation of collections—stamps, coins, flowers and especially minerals—and of tabulations of the facts that came to him through observation or reading. This characteristic of his orderly mind led him later to compile a "Table of Specific Gravities, Boiling Points and Melting Points of Solids and Liquids," which was accepted for publication in 1872 by Professor Joseph Henry, secretary of the Smithsonian Institution, who gave to the paper the general title "Constants of Nature, Part I." Further volumes under this title followed in 1876, 1882, 1888 and 1897.

After one year as professor of chemistry and physics at Howard University, Dr. Clarke accepted appointment in 1874 to the chair of chemistry and physics in the then new University of Cincinnati where he remained until, in 1883, he went to Washington as chemist of the United States Geological Survey and honorary curator of minerals of the United States National Museum, positions that he held until his retirement on December 31, 1924.

The investigations by Dr. Clarke and his associates in the Survey were of the most varied character, and the wide range of the topics of their many bulletins in the publications of the Survey affords abundant evidence of Dr. Clarke's striking ability as a director of research and as a chemist of unusual versatility and breadth of interest.

He early began the collection of data relative to the determination of atomic weights, and presented his first paper on the subject at a meeting of the Subsection of Chemistry of the American Association for the Advancement of Science, held at Saratoga in August, 1879. In 1882 there appeared from his pen a comprehensive monograph of 271 pages entitled "A Recalculation of the Atomic Weights," which attracted wide attention not only in this country but also in Germany and Norway, where similar revisions had been prepared. In 1892, the American Chemical Society requested him to prepare an annual report on the subject, and to compile annually a table of atomic weights for official use in this country. This he did until 1903, when an International Committee on Atomic Weights was created with Professor Clarke as chairman, a position that he continued to hold until 1922.

His article upon "The Relative Abundance of the Elements" appeared in 1889, and through all the following years it has stood as a classic on this subject.

One of his greatest services to chemistry in this country was in connection with the creation of the American Chemical Society. Up to 1873, chemistry had been given but scant attention in the meetings of the American Association for the Advancement of Science. In that year, at the meeting at Portland, Maine, four young men, C. E. Munroe, W. McMurtrie, H. W. Wiley and F. W. Clarke, presented a request that chemistry be more adequately recognized by the formation of a subsection of chemistry, now Section C. The request was granted, and the section held a successful meeting at Hartford in the following year. In 1876 the chemists of New York City organized a local society to which they gave the name American Chemical Society, and some eight years later another local society of chemists was formed in Washington. The American Association met at Cleveland in 1888, the chairman of the chemical section at that time being Dr. C. E. Munroe. Dr. Clarke wrote to him and suggested the formation of a really national Chemical Society. Dr. Munroe favored the idea, and after some three years of discussion of the project,

in which Dr. Clarke took an active part, a compromise proposal of the New York Society was adopted. This was, that if the chemists of the country would accept the name and charter of the New York organization, that society would form a local section of a truly national society, the Washington society to take the same action. This national society has now become the largest chemical society in the world, with eighty sections and over 17,000 members. Dr. Clarke was elected to the presidency of the society in 1901.

The numerous articles from his pen upon a wide variety of subjects that appeared in divers journals and magazines furnish abundant evidence of the breadth of his interest and the scope of his knowledge and of his gift of felicitous and convincing expression. The high esteem in which he was held by scientists both in this and foreign countries is shown by the number of honorary degrees that were conferred upon him, and by his election to honorary membership or emeritus life membership in American, English and Russian scientific societies.

Dr. Clarke was one of the most kindly and lovable of men, simple in his tastes and of a modesty that is so generally a characteristic of the really great. His sense of humor and ready wit gave to his conversation a delightfully piquant flavor and it was a most entertaining experience, which the writer often had the privilege to enjoy, to listen to his reminiscences, sometimes keenly critical, sometimes highly amusing, but always sympathetically appreciative, of the noted men whom he had known and of their scientific work. His was a long life, a happy and useful life, a life of helpfulness to others and of high achievement.

L. M. DENNIS

CORNELL UNIVERSITY

MEMORIALS

THE dedication of Fine Hall, Princeton University, will be held in the early fall at a time when it will be convenient for Miss Gwethalyn Jones, of Chicago, who, with her uncle, the late Thomas D. Jones, '76, of Chicago, gave the building to the university, to attend the exercises. The building, which was recently completed at a cost of $500,000, was given in memory of Dean Henry Burchard Fine, '80, who organized and developed the present department of mathematics of the university. It will contain all classroom and research work in mathematics. It is the seventh scientific building on the campus.

WE learn from the *Journal* of the American Medical Association that Dr. Cornelius A. Harper, Madison, president of the State Medical Society of Wisconsin, will dedicate a bronze tablet to the memory of Dr. William Beaumont on the site of Fort Crawford, near Prairie du Chien, on August 30. Speakers at the dedication ceremonies will be Dr. William Snow Miller, on "Beaumont the Man"; Dr. Walter J. Meek, "Beaumont the Physiologist," and Dr. Peter L. Scanlan, "Old Prairie du Chien." The site for the monument was presented to the medical society by the Daughters of the American Revolution. The inscription on the tablet is as follows: "William Beaumont, M.D., Pioneer in Physiology, born Lebanon, Conn., 1785; died St. Louis, Mo., 1853. At old Fort Crawford, one and one half miles northwest of this spot, one hundred years ago, Doctor Beaumont, a surgeon in the U. S. Army, performed those experiments on Alexis St. Martin which laid the foundation for our knowledge of digestion. In honor of his pioneer work this memorial has been erected by the State Medical Society of Wisconsin, 1931."

RECENT DEATHS

DR. ARISTIDES AGRAMONTE, professor of bacteriology and experimental pathology at the University of Havana and well known for his work on yellow fever, died on August 17, at the age of sixty-two years.

DR. WILLIAM H. HUNTER, chief of the division of organic chemistry in the school of chemistry at the University of Minnesota, died on August 19, aged forty-nine years.

DR. CHARLES H. SHATTUCK, vice-president of the Howard Pulp and Paper Company, and formerly professor of forestry at the University of California, died on August 13 at the age of sixty-four years.

MORGAN P. SWEENEY, for twenty-two years a member of the division of chemistry at the New York State Experiment Station at Geneva, died on August 6, following a brief illness.

DR. J. D. ROBERTSON, formerly commissioner of health and president of the board of education in Chicago, died on August 20, at the age of sixty years.

DR. ARCHIBALD BARR, chairman of the engineering firm of Barr and Strand, Ltd., and formerly Regius professor of civil engineering and mechanics at the University of Glasgow, died on August 6, at the age of seventy-six years.

SCIENTIFIC EVENTS

DISSOLUTION OF THE ROYAL BOTANIC SOCIETY

ACCORDING to an article in the London *Times*, the dissolution of the Royal Botanic Society at the end of this year was accepted as inevitable by a meeting of fellows held recently at the Royal Botanical Gardens. The lease of the gardens from the Crown does not expire until April, 1932, but the finances of the

society are attenuated and it is only by a reduction of the staff and the sale in the autumn of plants and other property that the remaining fellows may enjoy their facilities for a few months more and the society can meet its obligations in keeping with its honored traditions.

Mr. H. J. Greenwood, who presided at the meeting, said he was sorry that nothing had transpired since they last met of a hopeful character regarding the future of the gardens. Many of them, perhaps, had not been very sanguine that the decision would be materially changed. Efforts had been made by a large number of fellows, and more particularly by Colonel Moore, to keep in touch with the Minister of the Crown affected, but, in view of the grave situation in the world, members of the cabinet would not be able to give consideration to the matter of the gardens at the present time. Apart from that, he reminded the meeting that it was determined some years ago that the whole of the Crown leases in private hands were to be reviewed and treated in an economic way. When, in the early days of the consideration of the future of the gardens, the council made an offer of £2,000 for a further lease, if granted, they were advised that the sum likely to be required for this inner circle would probably be £3,000 to £5,000 a year. It was obvious that even in a mood of optimism efforts to meet such a rent would have been doomed to failure. In any case they had to face the definite statement that there would be no renewal of the lease.

The Duchess of Hamilton, who elicited the fact that the curator had the longest service of the officials of the society who were to go, paid a tribute to the work of Mr. North, and recalled that he began the cultivation of the soya bean, which might one day be of great help to agriculture.

The chairman, having intimated that it was proposed that a testimonial should be opened for the staff of the society, accepted a proposal that it should be done at once, and subscriptions were made during and at the close of the meeting. It was also stated that the government had asked for, and had been given, particulars of the age and length of service of the staff.

Colonel T. C. Moore, M.P., gave a short account of his efforts to secure the preservation of the gardens. While hopes had not actually materialized, he said, they were not without possibility of coming to fruition. With the support of the council he had approached the Pilgrim Trust for a contribution towards the upkeep of the society, and through Sir Ernest Graham-Little had tried to find out what the London University Senate might do. The Pilgrim Trust did not meet until the latter part of September, but full details had been collated for them. To Mr. Lansbury he had submitted alternative suggestions. One, that, subject to the Pilgrim Trust and the university cooperating to maintain the integrity of the society, the lease should be renewed under new and more democratic conditions, had not much chance of acceptance. The other was to agree that the society should lapse and that the government should take over the gardens and administer them, offering facilities to subscribing fellows, but providing for the admission of the public, and with two free days. That was a scheme which he thought might appeal to Mr. Lansbury, and it had been promised full consideration.

OPPORTUNITIES FOR EMPLOYMENT OF ENGINEERING GRADUATES

A FORTY per cent. increase in enrolment in the engineering schools of the country during the past five years narrows professional possibilities in some of the fields, as the saturation point approaches, according to a statement made to a representative of the *U. S. Daily* by Mr. W. C. John, specialist in professional education at the Federal Office of Education.

The total enrolment in 145 leading engineering schools reached 78,685 during 1930–1931, of whom 12,161 were undergraduate seniors and 2,939 students of graduate engineering.

The problem of the placement of graduates of engineering schools becomes more difficult as the number of students increases. Reports collected by Mr. F. L. Bishop, secretary of the Society for the Promotion of Engineering Education, indicate that but 38.2 per cent. of the graduates of 88 institutions have been placed this year. The report involved 5,866 graduates, of whom only 2,240 obtained positions.

The latest statistics on engineering education are now in process of compilation by the Office of Education and will soon be available for public distribution. These statistics will show a great increase in the number of students pursuing some phase of engineering. The four leading fields are electrical, mechanical, civil and chemical engineering, with mining and metallurgy ranking fifth in popularity.

Nearly 20,000 students were enrolled in electrical engineering courses alone in 1930–1931. Of these, 18,565 were undergraduates. More than 15,500 were pursuing mechanical engineering with over 15,000 enrolled as undergraduates.

Civil engineering ranked third in popularity with a total enrolment of over 14,500, of which 13,813 were undergraduates. Next in order was chemical engineering which mustered over 9,600. Of these, 9,154 were undergraduates. Mining and metallurgy were represented by nearly 3,000. Mr. Bishop's study on placement of students from the 88 institutions reporting indicates that 33.4 per cent. of the electrical engineering group were placed, 41 per cent. of the mechanical, 37.5 per cent. of the civil and 46.3 per

cent. of the chemical. In mining 45.1 per cent. were placed and in industrial engineering, 44.2 per cent. It was found that institutions west of the Mississippi placed about 3 per cent. more students than those east. Colleges in urban centers have placed about 5 per cent. less of their graduates.

The survey covers enrolments in 41 separate fields of engineering to which are added special and unclassified groups.

A study of the total distribution of students of engineering throughout the four years shows that more than 50 per cent. do not reach the senior year while 2,360 enter graduate work.

For the session 1930–31, a total of 25,332 students enrolled in freshman courses, 19,631 in sophomore courses, 16,262 in junior and 12,161 in senior courses. There were 73,386 undergraduates.

In recent years there also has been a notable tendency for students to continue higher studies after completing their undergraduate work.

THE NEW YORK STATE GEOLOGICAL ASSOCIATION

THE seventh annual field meeting of the New York State Geological Association was held at Port Henry on May 15 and 16, under the presidency of Dr. Harry N. Eaton, of Elmira College. Dr. O. D. von Engeln, of Cornell University, was secretary. About 115 persons were in attendance representing twenty different institutions. Dr. D. H. Newland, Dr. R. Ruedemann and Mr. C. A. Hartnagel, of the New York State Museum, acted as field leaders. The region chosen for the excursions is one of great natural beauty, rich in historic associations and classic from the standpoint of pre-Cambrian and mining geology.

Upon meeting at Fort Ticonderoga on Friday, the party moved to Fort Crown Point and Port Henry studying the fine exposures of the early Paleozoics of the Crown Point Peninsula, and observing the glacial deposits and evidences of marine transgression. North of Port Henry were seen pre-Cambrian igneous rocks, metamorphosed sediments of the Grenville series, and faults between the pre-Cambrians and the Paleozoics.

During Saturday forenoon a trip was made to Mineville (six miles) to study the great magnetite ore body in the pre-Cambrian and the mines of the Witherbee-Sherman Company which have been worked for many years.

At the dinner on Friday night talks explanatory of the local geological features were made by Drs. Ruedemann and Newland, and Dr. H. L. Alling showed a series of microphotographs to illustrate the origin of the magnetite ore.

The invitation of the University of Rochester to act as host for the meeting in 1932 was accepted. Dr. H. L. Alling and Dr. J. E. Hoffmeister were elected president and secretary, respectively, for the ensuing year.

SYMPOSIUM OF THE AMERICAN CHEMICAL SOCIETY

A SYMPOSIUM on "New Research Tools" will be held in Buffalo on August 31, as the opening event of the eighty-second meeting of the American Chemical Society. The chairman of the symposium will be Dr. Karl Taylor Compton, president of the Massachusetts Institute of Technology, who in cooperation with other investigators has selected twelve new research tools for discussion.

The twelve fields to be discussed are roughly divided into three groups. Speakers and their topics on radiation and atomic structure are: Professor Donald H. Andrews, the Johns Hopkins University, "The Use of Raman Spectro in Qualitative Analysis"; Professor George L. Clark, University of Illinois, "X-Rays as a Research Tool in Chemistry and Industry"; Professor Worth H. Rodebush, University of Illinois, "Molecular Beams"; Professor Charles P. Smyth, Princeton University, "Dipole Moments"; Professor Harold C. Urey, Columbia University, "Molecular Spectra."

Speakers at a second group of subjects, dealing with new advances and applications of certain practical tools, are: Dr. Saul Dushman, General Electric Research Laboratory, "New Gauges"; Dr. Per K. Frolich, Standard Oil Development Company, "Catalysis"; Professor Frederick G. Keyes, the Massachusetts Institute of Technology, "High Pressure Technique"; Dr. W. A. Peters, Jr., E. B. Badger and Sons, New York, "Distillation"; Dr. Robert B. Sosman, U. S. Steel Corporation, "High Temperature Technique"; Dr. Lewis R. Koller, General Electric Research Laboratory, "High Temperature Control."

Various aspects of micro-analysis comprise a third group of topics, the speakers being: Professor Fred Allison, Alabama Polytechnic Institute, "Microanalysis of Solutions"; Professor E. M. Chamot, Cornell University, "Micro-analytical Methods as Time and Labor Savers"; Dr. Frederick G. Cottrell, U. S. Department of Agriculture, "Micro-analysis of Gases"; Dr. J. B. Nichols, E. I. du Pont de Nemours & Co., "The Ultra-Centrifuge and its Field of Research."

The committee which, with Professor Compton, selected the topics and speakers included the following representatives of pure science: Professor Roger Adams, head of the department of chemistry of the University of Illinois; Wilder D. Bancroft, professor of physical chemistry of Cornell University; Dr. Frederick G. Cottrell, of the Bureau of Chemistry and Soils of the U. S. Department of Agriculture; William D. Harkins, professor of chemistry, Univer-

sity of Chicago; Dr. Arthur A. Noyes, director of the Gates Chemical Laboratory of the California Institute of Technology; Professor Hugh S. Taylor, chairman of the department of chemistry at Princeton University.

Committee members representing industrial research groups were: Dr. Harrison E. Howe, editor of *Industrial and Engineering Chemistry;* Dr. John Johnston, director of research, U. S. Steel Corporation; Dr. Arthur D. Little, of A. D. Little, Inc., Cambridge, Massachusetts; Dr. C. E. K. Mees, director of research, Eastman Kodak Company; Dr. Willis R. Whitney, director of research, the General Electric Company; Dr. Robert E. Wilson, vice-president in charge of development, Standard Oil Company of Indiana.

SCIENTIFIC NOTES AND NEWS

THE thirty-fourth anniversary of the discovery by Sir Ronald Ross of the transmission of malaria by anopheles mosquitoes was celebrated on August 20 at the Ross Institute in Putney, London. Dr. William H. Welch, professor of the history of medicine at the Johns Hopkins University, and Mr. John Masefield, poet laureate of Great Britain, gave the principal addresses.

DR. WILLIAM J. HOLLAND, director emeritus of the Carnegie Museum, Pittsburgh, celebrated his eighty-third birthday on August 16.

DR. LINUS PAULING, professor of chemistry at the California Institute of Technology, will receive the A. C. Langmuir Prize at the Buffalo meeting of the American Chemical Society on September 2. The Langmuir Prize, awarded for the first time this year, is bestowed "in recognition of the accomplishment, in America, of outstanding chemical research by a young man or woman preferably working in a college or university." It emphasizes, according to the announcement, the debt industry owes to pure science. Dr. L. V. Redman, vice-president of the Bakelite Corporation, Bloomfield, New Jersey, and president-elect of the American Chemical Society, was chairman of the jury of award, other members of which were: Professors Roger Adams, University of Illinois; S. C. Lind, University of Minnesota; Farrington Daniels, University of Wisconsin; Charles D. Hurd, Northwestern University; Arthur E. Hill, New York University, and Hobart H. Willard, University of Michigan.

MR. FRANK J. TONE, president of the Carborundum Company, Niagara Falls, has been awarded the Jacob F. Schoellkopf gold medal of the western New York section of the American Chemical Society. The award is made for a major advance in science embodying the spirit of research in industry. The medal will be formally presented at Buffalo, September 2, at the eighty-second meeting of the American Chemical Society by its president, Professor Moses Gomberg, of the University of Michigan, following the annual presidential address. Mr. Tone will deliver an address after the presentation on "The High Temperature Products of Silicon."

MR. HENRY ALLEN MOE, secretary of the John Simon Guggenheim Memorial Foundation, has announced the names of additional members on the advisory board of the foundation. They include Dr. Thomas Barbour, professor of zoology and director of the Museum of Comparative Zoology, Harvard University, and Dr. Florence R. Sabine, member of the Rockefeller Institute for Medical Research.

DR. W. E. TOTTINGHAM, of the University of Wisconsin, was elected president of the American Society of Plant Physiologists and Dr. R. B. Harvey, of the University of Minnesota, was elected vice-president in the recent election. Dr. M. A. Gardner will continue as secretary for another year.

DR. THURLOW C. NELSON, professor of zoology at Rutgers University, has been elected president of the National Shell Fisheries Association at the convention of that organization and the Oyster Growers' and Dealers' Association of North America, Inc. He succeeds Mr. Lewis Radcliffe, of Washington, D. C. Other officers elected were Dr. R. V. Truitt, of the University of Maryland, *vice-president;* Dr. Herbert F. Prytherch, of Washington, D. C., *secretary,* and Howard W. Beach, of New Haven, *treasurer.*

DR. WILLIAM GERRY MORGAN, past-president of the American Medical Association, has accepted the position of dean of the School of Medicine at Georgetown University. He will continue to serve as regent of the university.

DR. THOMAS FREEMAN COPE has been promoted from assistant professor to professor of mathematics at Marietta College.

MR. EARL CHURCH has been promoted from assistant professor of mathematics to associate professor of photogrammetry at Syracuse University.

MR. HERBERT HOOVER, JR., son of the President of the United States, has been appointed assistant professor of business economics and radio engineering at the California Institute of Technology.

MR. F. B. ISELY, dean and professor of biology at the Texas Woman's College, has been appointed professor of biology at Trinity University, Waxahachie, Texas.

DR. ROBERT E. LANDON has resigned from the U. S. Geological Survey and has accepted a teaching position in the department of geology at Colorado College, Colorado Springs.

MR. DAVID KEILIN, F.R.S., of Magdalene College, has been elected Quick professor of biology at the University of Cambridge, succeeding Dr. G. H. F. Nuttall, who has held the chair since it was founded in 1906.

DR. G. L. KELLEY, of Harvard University, has been appointed to supervise the research work in the manufacture of pressed steel coaches of the Pressed Steel Company of Great Britain.

DR. ROBERT A. MILLIKAN, director of the Norman Bridge Laboratory of Physics and chairman of the executive council of the California Institute of Technology, is on his way to Europe. He goes to Germany as exchange fellow of the Oberlaender Trust of the Schurz Memorial Foundation, and in England will represent the National Academy of Sciences, of which he is foreign secretary, at the centenary meeting of the British Association and the Faraday and Maxwell celebrations.

DR. L. O. HOWARD, who recently retired after more than fifty years' service in the U. S. Bureau of Entomology, having been chief of the bureau from 1894 to 1927, is about to leave Honolulu for France, stopping on the way at several places of entomological interest. It is his intention to remain in France for at least a year.

DR. R. S. BASSLER, of the U. S. National Museum, is spending two months in museum and field-work in England, Austria and Hungary. His work primarily will be devoted to obtaining material for the increase of the Frank Springer collection of fossil echinoderms. In connection with this work he intends also to secure collections of Post-Paleozoic fossils from the Vienna basin and the Hungarian plain much needed for the museum.

DR. W. REID BLAIR, director of the New York Zoological Park, has sailed to Europe to spend about seven weeks in connection with the plans made for a cattle group to be established at the park.

PROFESSOR FRANK C. BAKER, curator of the Museum of Natural History, University of Illinois, is spending the summer in a molluscan survey of Illinois, particular attention to be given the land species. Two seasons are planned in the field following which a manual of the land mollusca of the state will be prepared. Mr. Dale Foster, a graduate student of the department of zoology of the University of Illinois, will assist Professor Baker.

A FIVE months' leave of absence has been granted to Dr. L. O. Overholts, of the department of botany at the Pennsylvania State College, to initiate a special research for the federal government. Dr. Overholts will spend several months in the forests of Louisiana studying timber diseases, and later go to Washington to classify and tabulate the findings.

PROFESSOR H. L. BOLLEY, dean of biology of the North Dakota Agricultural College, botanist and plant pathologist at North Dakota Experiment Station, who was granted leave of absence from the institution in July, 1930, for the purpose of making botanical and agronomic studies in Argentina and other of the more temperate regions of South America, has returned to the North Dakota Agricultural College and has brought back with him a number of specially selected seeds, particularly from the flax crop in Argentina and Uruguay. Professor Bolley was particularly interested in the methods of cropping pursued in the Argentine cereal cropping zones and paid special attention to the relationship of their methods of cropping as affecting the presence of diseases of the cereals and small grain crops, particularly of flax.

DR. T. WAYLAND VAUGHAN, of the Scripps Institution of Oceanography of the University of California, in cooperation with Mr. M. L. Maitland, of Long Beach, is aiding in the mapping out of a program of investigations to be undertaken this summer. Mr. Maitland has for several years been making a comparative study of recent and fossil foraminifera. They are planning the dredging of approximately 200 samples of sea bottom from shallow to deep waters between Long Beach and Catalina Island. A special fund has been given by the National Research Council for this work.

THE New England Intercollegiate Geological Excursion will take place this year in Montreal at the invitation of the department of geology of McGill University. The meetings will be held on Saturday, Sunday and Monday, October 10, 11 and 12. On Saturday members of the party will study the geology of Mount Royal and St. Helen's Island. On Sunday there will be two excursions, the first to study the stratigraphy of the neighborhood of Montreal, and the second to the Precambrian of the Laurentians, and on Monday structure and stratigraphy of the Appalachian front in Southern Quebec. Full details will be sent to members later. Others wishing further

information may write to T. H. Clark, department of geology, McGill University, Montreal, Quebec.

THE International Illumination Congress will be held in Great Britain from September 1 to 19. Provision is made for visits to London, Glasgow, Edinburgh, Sheffield, Buxton and Birmingham, following which the sessions of the International Commission on Illumination will be held at Cambridge. Throughout the visits to the cities named, the technical sessions, at which more than a hundred papers will be presented, will alternate with trips and social events.

THE next International Congress of Mathematics will be held at Zurich from September 4 to 12, 1932.

THE sixth Natural Science Congress of the Dutch Indies will be held at Bandung, Java, from September 22 to 26. The congress will meet in six sections.

THE Italian Anatomical Society will hold its third congress at Palermo in October. The topics on the program are: morphogenesis of derivatives from the intestine, with an official paper by Professor Bruni, of the University of Parma, and new data on the histochemistry, morphology and histophysiology of cellular lipoids, with an official paper by Professor Ciaccio, of Messina. Professor Luna, of the University of Palermo, will be secretary of the congress.

THE French-American Committee of the Curie Institute, Paris, according to the Paris correspondent of the *Journal* of the American Medical Association, has been organizing receptions in honor of the nations of the Americas. Twenty-two countries were represented. The first reception was held at the Radium City, which was erected with the aid of subscriptions in which these countries participated. The receptions were attended by diplomats, savants, industrialists, literary men and artists. Professor Regaud, director of the institute, and Madame Curie and daughter were the host and hostesses, respectively, in the department for the technical study of radioactivity and the cancer department. Madame Curie gave a lecture on radium and exhibited to the visitors the tube, preserved in a glass case, that contains the first particles of radium secured by her husband and herself.

MORE than 100 official delegates, representing 30 countries, and more than 400 other participants attended the fifteenth International Congress of Agriculture in Prague, Czechoslovakia, which was held from June 5 to 8. Mr. Asher Hobson, in charge of the Foreign Agricultural Service, U. S. Bureau of Agricultural Economics, was an official delegate to the congress, and has recently returned from abroad. The congress this year was divided into seven sections, dealing with agrarian policy and rural economy, agricultural teaching and extension, agricultural cooperation, plant production, animal production, agricultural industries and rural women. Mr. Hobson was one of the three principal reporters for the section on agrarian policy and rural economy. The discussion at the congress centered on the world wheat crisis, with special reference to preferential treatment to grain from eastern European countries by western European countries. The export quota system also received attention. The congress did not commit itself definitely on either of these subjects.

MESSRS. BAILLIERE, TINDALL and COX are publishing shortly for the Bentham Trustees the "International Address Book of Botanists" which has resulted from the resolution of the fifth International Botanical Congress of 1930. This will be on lines somewhat similar to Dorfler's "Botaniker Adressebuch," and will contain the names of some 13,000 to 14,000 botanists and botanical institutions, etc., in all parts of the world. These will be arranged alphabetically by countries, will be printed in the majority of cases in the language of the country in Roman script and will be provided with an index of personal entries and geographical indices. In the publication of the book the International Committee has received assistance from the Bentham Trustees and from the Carnegie Corporation of New York.

IT is reported in the daily press that the island of St. Kilda which lies off the Hebrides on the northwest coast of Scotland, and which was evacuated by its few remaining inhabitants last year, has now been bought as a bird sanctuary. It has always been the resort of countless seabirds and is well suited for the purpose. The island has belonged to the Highland chieftain Macleod of Macleod for over 300 years.

THE annual reports for 1930 of the British Museum, Bloomsbury, and the Natural History Museum, South Kensington, were issued recently. The summary in the London *Times* states that visitors to the British Museum increased during the year to a total of 1,201,639, as compared with 1,191,758 in 1929, and 1,181,617 in 1928. This increase was entirely due to a rise in the number of Sunday visitors, the week-day numbers having decreased by 412. The total number of students who visited particular departments also rose by 13,186 to the highest total yet recorded, 285,538. This increase was chiefly found in the reading room and manuscript room. The number of art students visiting the sculpture galleries fell from 1,671 to 659, the lowest recorded in recent years. Attendances at the Natural History Museum fell from 541,198 in 1929 to 506,407 in 1930. The scientific staff of the museum was increased by 15 and the subordinate staff

by 24. Economic advice was given by the Department of Zoology on the protection and control of elephants in Africa; the control of the musk-rat; occurrences of parasitic worms in man and animals in Nyasaland, Morocco, Algiers, the Sudan and East Africa; and the ravages of shipworm at Haifa and Rangoon. In the entomological department work was done in relation to insects causing or transmitting disease, pests of stored products, boring insects and farm and garden pests.

THE Illinois State Department of Health at Springfield has issued a statement in which it is noted that the circumstance that fatalities from diarrhea and enteritis jumped from 1,306 in 1929 to 1,531 in 1930, a very significant reversal in the recent trend of mortality from these causes. It is pointed out that fatal intestinal infections, especially in children, nearly always reflect errors in diet. Either the food is not wholesome or the wrong kinds of foods are consumed. Economic distress has doubtless led many families to modify radically their food supplies. Frequently, this has cut out from the diet of children, or reduced beyond the point of safety, such indispensable foods as milk and eggs. No medicinal or specially prepared vitamin products can take the place of milk and eggs in the food supply of children. Over 90 per cent. of the mortality from diarrhea and enteritis occurs among children under 2 years old. A sharp decline in milk and egg sales during 1930, as compared with 1929, indicates that the difficulty is associated closely with the economic situation. From a health standpoint, the statement says, it appears that a serious disturbance of the family food supply should be the last matter affected by a retrenchment program. Wisely expended, a very small *per capita* outlay will provide a well-balanced diet at prevailing food prices.

THE Hungarian correspondent of the *Journal* of the American Medical Association reports that Count Kuno Klebelsberg, Hungarian minister of public instruction, recently announced in the National Assembly that the American Rockefeller Foundation had entered into cooperation with the University of Sciences in Szeged and the Biological Research Institute in Tihany, and had granted 1,018,000 pengö for the two institutes. According to the accepted plan the Szeged University will devote from this sum 678,300 pengö to the equipment of natural history and theoretical medical scientific institutes, and to cover the current expenses of scientific investigations the foundation allows 200,000 pengö, about $40,000. For the erection of a glasshouse at the biological institute in Tihany, on the bank of the Danube, the foundation allowed 70,000 pengö, and for covering the current expenses of the next five years it gave 50,000 pengö. During this period also the Hungarian state will contribute a large sum to the budgets of these institutions. The correspondent of the *Journal* writes: "The Hungarian public received this report with immense enthusiasm; not only is the princely sum which was donated appreciated, but still more so the moral achievement. The foremost and richest scientific institution of the world gave a helping hand to two Hungarian scientific institutions from which they obviously expect results on behalf of the entire human family. With this act the Rockefeller Foundation not only obliged the Hungarian state and community, but it made a great service also to the universal natural sciences and to the search for truth. The minister, when expressing gratitude at the sitting of the National Assembly, spoke, in fact, from the heart of the whole Hungarian nation."

ERRATUM: In the issue of SCIENCE for August 14, on page 171, the bequest of Dr. Richard Alexander Fullerton Penrose, Jr., was incorrectly stated owing to a line having been misplaced after the pages had been made up. The residue of Dr. Penrose's estate, valued at $1,000,000, is divided equally between the American Philosophical Society and the Geological Society of America.

DISCUSSION

WHY THE ANGIOSPERMS ARE OLD

A CONSISTENT course of leaf change from Carboniferous times down, easily leading into trident (Sassafras), bladed (Magnolia), and other angiospermous leaf types through a gradually developed net venation, or especially through invasion of a marginal net, has been outlined with reference to type fossils elsewhere. It is believed this view of a wide-spread and gradual development of the foliar features of modern forest types taken in general is a valid one, though unlikely to at once appeal to those unfamiliar with the manner in which fossil leaf evidence bulks up in the field. No less, there should be some further recourse of proof. Does not such come into view when the classification of vascular plants is enough simplified?

Now in the first instance (as indicated by Jeffrey), all stem structures fall into two great series or lists, the lycopsida and the pteropsida. From the former might be separated the sphenopsida. Be this as it may, what is held here is that neither the sphenopsids nor the lycopsids include true floral antecedents, and that fructification in the lycopods and in selaginella

is non-zonate and therefore has never had anything to do with the origin of the cones of conifers or the flowers of angiosperms, while in the second instance the pteropsida include the great lines of seed plants, probably all going back beyond the Carboniferous as follows:

ARCHAEOSTROBILE (The protospermatophyta, primitively amphisporangiate).	I. *Metastrobile* (inflorescent)	Cordaites Ginkgos Conifers
	II. *Anthostrobile* (floral)	Gnetales Angiosperms Cycadeoids
	III. *Neostrobile* (carpellary)	Cycads Lyginopterans Medullosans

This scheme portrays a unit view of cone, or of primitive strobilar and floral structure. It could be called the view or theory of *monomorphy*. It suggests, if it does not even emphasize conformity in a course of variation which throughout all the lines of seed plants extends back to, and takes its beginnings in amphisporangiate primitives just above the algae. That for instance searching anatomical study of angiospermous floral structures does not confirm the claim for the presence of "polymorphy" or complexity in emplacement of floral parts (*Cf.* Eames), is a strong supporting point. That the cycadeoid floral origin and history runs parallel to that of the angiosperms must also be believed. The primitive form would alike be a zonate and amphisporangiate spiral. It need not be supposed that in this the gnetaleans varied. Nor is it likely that the cones of conifers had an entirely separate origin.

That the Cordaites are not better known is perhaps the greatest tragedy of present-day fossil botany. Evidently much more will be learned about this exceedingly varied group. It seems at present to be a fundamentally inflorescent group with the male flowers and the female very much alike if the stamens may be considered analogous to carpels and those of course to modified leaves. The group is evidently dioecious or monoecious. Could it have been derived from an amphisporangiate ancestry which through branching developed the reproductive axis of limited growth and then monoecism? With regard to the dioecious Ginkgo, except for advance in wood structure the features are Cordaitean; while if the stalk bearing the two ovules is an axillary shoot as seems likely, a cone homology with the cycads also exists. As to the conifers, they are now and have long been a homogeneous group, the most specialized of all gymnosperms. Did they ever include, or were they derived from a primitive amphisporangiate type which after branching became monoecious, then partly dioecious? Such might be defined as a hemiconifer. In conifers the stamens are still simple; but the seed scales are axillary and utterly modified. Hence it is not so sure that the basal and zonate spirals of stamens in abnormal amphisporangiate axes have no reminiscent meaning.

Turning again to Group II of the scheme it is noted that in view of the pine-like character of the *Gnetum* wood, and the fact that the amphisporangiate flower of *Welwitschia mirabilis* may even be primitive for all Gnetaleans, the question whether such floral unit was in some like manner antecedent in pines and Cordaites can not be called absurd. In any case an extreme antiquity is suggested for all of these types and groups. Unfortunately amongst the cycadeoids where it might most be hoped to answer questions of antiquity, evidence still fails. Notwithstanding the certainty of a long and cosmopolitan history the flowers are not seen beyond the Triassic, by which time despite a general simplicity of structure, modernity of type and form had already been reached. The supposed affinities with the cycads and seed ferns afford little aid in picturing the antecedent forms. Though, however the cognate facts and inferences may all fall, can the angiosperms in turn have had any other than a very remote and always amphisporangiate ancestry? It is held not. Only polyphyly explains.

In Group III the cycads could at least be derivatives of monoecious forms, while the sporophylls are of course analogous to stamens and carpels in angiosperms. The difficulty of deriving the angiosperms from within this complex, at least as homogeneous as either of the preceding, rests in the absolute lack of evidence for the presence within it of amphisporangiate axes of limited growth. The numbers are now few, giantism is intense, and apparently fertile recessiveness in the cones never occurs. Nor is much of suggestion here afforded by the seed ferns because their microphyllous variants and antecedents are not seen, and are as difficult to picture as any other hypothetic types. The medullosans are really the aberrant pteridosperms on which aside from the isolated and odd Caytonia must rest the first possibility of angiosperm affinity. Their mimicry of monocot stems was long overlooked. The tracheids are of a form which could easily give rise to vessels. The branching is peculiar.

The great evolutionary fact is that whereas in dicots and cycadeoids stem branching supports the reproductive axis of limited growth, free branching in monocots is confined to the flowering shoots. The shoots have a remote analogy to inflorescent cones. The simple cone (as seen in cycads), the flower, the inflorescent cone or strobilus of conifers, cauline branching of dicots and conifers, and the reproduc-

tive branching of the endogenous and columnar monocot, mark out the great ways of higher seed plant evolution. And when these ways are followed back with due attention to the most logical grouping of the seed plants and the fossil record, it is seen that flowers must go so far back that it is reasonable to hypothesize archaic forms above the algae leading into plants little else than a stalk bearing a few leaves followed above by micro- and then megasporophylls. According to such conceptions, in the subsequent course of phytologic evolution foliage leaf advance often tended to be thrown back into the megasporophyll, while flowers always tended to remain small, cones always to reach giantism. Whence as in the above classification, it seems reasonable to consider the flowering types as the older line and to place them between the simple cone types (cycads) on the one hand and the inflorescent strobilar types (conifers) on the other.

In looking over present day plants, and back through time, nothing is so deceptive as megaphylly and giantism, unless perhaps the mixed cones of selaginella and those of lepidodendron. It is too much to expect directly from fossils the fuller history of flower and cone. The sporophyll, cataphyll and stipules, the rôle of branching, of monoecism and dioecism, must all be considered *per se*. Only through analysis aided by diagram is it seen that the flower has always been just an emplacement of sporophylls at first spiral, then whorled and cyclic. And then only does unity in the classification—accord in structure and origin begin to appear.

Moreover, botanists have not sufficiently emphasized the fundamentally significant fact that precisely the forms concerned in plant descent throughout the ages, therefore the relatively extinct forms, should not be expected to occur as left-overs in surviving floras. Mainly the specialized types, or those of peculiar environments are the ones seen as fossils. The assumption that the visible fossil antecedents are numerous is an utter fallacy. It too easily leads to the thought that the dint of a hard analysis and approach to the problems of seed plant origin from every possible view-point may be escaped.

G. R. WIELAND

CARNEGIE INSTITUTION

THE OCCURRENCE OF PHYLLOERYTHRIN IN THE DIGESTIVE SYSTEM OF HERBIVOROUS ANIMALS

IN 1903 Marchlewski[1] described a compound obtained from the fresh excrement of a cow fed entirely on grass and gave to this compound the name of phylloerythrin. In the same year Loebisch and Fischler[2] isolated bilipurpurin from ox-bile. Marchlewski later showed that bilipurpurin and phylloerythrin were identical compounds and that they were the decomposition products of chlorophyll formed by the herbivorous animal. H. Fischer and O. Süs[3] used phaeophorbide *a* to prepare phaeoporphyrin a_6 and a_5 and from these compounds they succeeded in preparing phylloerythrin, thus proving chemically that phylloerythrin originates from chlorophyll.[4]

The presence of such a chlorophyllous product as phylloerythrin in the bile and the feces of herbivorous animals is of considerable interest; and since, in so far as we are aware, no one has determined the place or mode of origin of this substance in the body, the present work was undertaken with these objects in view.

We have demonstrated that phylloerythrin occurs in the third stomach (omasum) of cows and sheep which were fed on a normal winter diet containing chlorophyll. The stomach contents were collected at the slaughter house about fifteen minutes after the animals were killed and the material taken to the laboratory and extracted with a chloroform-pyridine mixture. An ether solution of the extracted pigments was fractionated with hydrochloric acid and the eight to nine per cent. fraction gave an absorption spectrum in pyridine-ether identical with phylloerythrin. This latter substance was crystallized from pyridine-alcohol. At the present time a sufficient quantity for a combustion analysis has not been obtained, but this will be done later. Using the same procedure as that used for the third stomach, we demonstrated spectroscopically that traces of phylloerythrin occur in the first stomach (rumen) of the cow and the sheep. The third stomach contents of a calf on a milk diet gave no trace of phylloerythrin.

Further work on the physiological formation of phylloerythrin outside the animal body is now in progress. The experimental details and a complete summary of the literature pertaining to this work will be published elsewhere a little later.

O. L. INMAN

PAUL ROTHEMUND

C. F. KETTERING FOUNDATION FOR THE STUDY OF CHLOROPHYLL AND PHOTOSYNTHESIS, ANTIOCH COLLEGE

[1] *Bull. int. de L'Académie Polonaise des Sciences et des Lettres.* Série A, p. 638–642, 1903.

[2] *Monatsch. f. Chemie.*, pp. 335–350, 1903.

[3] Ann. vol. 482, p. 225–232, 1930.

[4] H. Fischer, O. Moldenhauer and O. Süs, Ann. 486: 107–177, 1931, have shown that phaeoporphyrin a_6 and a_5 are identical.

FRESH WATER MEDUSAE IN OKLAHOMA

THE finding of *Craspedacusta ryderi*[1] in an Oklahoma stream seems to be of sufficient general interest to warrant this note. All other records of this interesting form are from localities east of the Mississippi River.[2,3,4,5]

On September 6, 1930, Phillips first noticed the medusae in Lukfata Creek, a tributary of Little River, about one quarter mile north of Broken Bow, Oklahoma (Sect. 27 or 34, T6S–R 24E). Individuals were also seen in Yanubee Creek in Sect. 17, T6S–R 25E. Individuals were at first very numerous and were seen and collected at intervals during the three weeks following their discovery. The number was so great that "the water was almost blue with them."

We are indebted to Mr. Glen R. Durrell, district forester, and Mr. W. H. Mitchell, assistant district forester, for properly shipping us the specimens.

The part of Lukfata Creek where these medusae were taken was a relatively clear pool approximately 200 feet by 25 feet. The depth averaged 4 to 5 feet. The stream is known to have been "scoured out" this spring by floods; since that time the water has remained low. The specimens were found in water at least three feet deep near the center of the pool. The temperature of the water at that time was between 70° and 75° F.

The activity of the medusae consisted of slow movements in a vertical direction. The upward excursion resulted from repeated contractions of the umbrella. The return to the bottom of the pool was brought about by one of two methods; first, by "side slipping," and second, by turning over completely and propelling themselves downward. This cycle was completed about twice in a minute. They did not become active until the sun was fairly well up.[6]

No hydroid has been found as yet, but it is hoped that additional work next year may reveal this stage.

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THE "FIRE STOPPER"

RECENT papers in SCIENCE[1] discussing the use of the divining rod recall to my mind a conversation which took place in my presence, a few years ago, on a topic which was new to me. Nor have I since seen or heard any reference to this subject. The speakers were descendants of the German racial group frequently spoken of as "Pennsylvania Dutch," whose ancestors had migrated to the southwest.

Night had come to the road camp astraddle the Virginia-West Virginia boundary. The bee tree had been cut, the honey secured and the men were drifting back to camp. Among the first was old Paul Straus. He did not like these expeditions. He complained that a bee would fly a hundred yards to attack him no matter how many men there were closer to the bee tree. But at this safe distance in the darkness he became reminiscent.

"Old Jo Kirschbaum," he said, "could go right up to any tree. They never bothered him. I've seen the bees just buzzing all around his head—yellow jackets, too. He used to say you'd be all right as long as you didn't do anything to make them cross."

"Who was that, Mattie's father?" asked Homer Heatwole.

"No, Sam's uncle, old Oscar's brother."

"Oh, yes, I remember now. He could stop fire, too, couldn't he?"

"Yes, he'd just walk through the woods where there was fire coming, and when the fire got up to where he'd been walking it would just stop burning. I wish I knew how he did it. I gave him five dollars once to teach me how and he said he would some time, but he never got around to it. Always busy with something else he couldn't leave. He's gone now. He told me once if he taught it to anybody else he'd lose the power himself."

"Were you down at that fire on the Hunter land that he stopped?" asked Homer.

"No, but I saw the place afterwards."

"So did I. There was one place there where there were dry pine tops piled up and he walked across them and the fire stopped right there in the middle of the pile."

"Yes, I remember seeing that, too. Old Jo certainly had the power. There are not many that have."

The rest of the crew were coming in now with the lanterns and honey and the conversation turned to the subject of past and future bee tree hunts and present drinking water. The discussion was not resumed either then or later.

I wonder whether other readers of SCIENCE have ever come in contact with persons holding this belief. There is of course the possibility that we are dealing with an imaginative story of the type of the "Paul

[1] The authors wish to thank Dr. F. Payne for checking their tentative identification of these specimens.

[2] C. W. Hargitt, SCIENCE, 26: 638, 1907.

[3] H. Garman, SCIENCE, 44: 858, 1916.

[4] F. Payne, *Jour. Morph.*, 38: 387, 1924; *Biol. Bull.*, 50: 433, 1926.

[5] W. E. White, *Biol. Bull.*, 59: 222, 1930.

[6] H. Garman, SCIENCE, 60: 477, 1924.

[1] C. A. Browne, "Observations upon the Use of the Divining Rod in Germany," SCIENCE, 73: 84–86, 1931.

I. P. Tolmachoff, "The Use of the Divining Rod in Alaska," SCIENCE, 73: 365–366, 1931.

Bunyan" yarns. But my observations of those men at other times would indicate that they were not given to this type of exaggeration. Apparently they were sincere in their belief that the incidents actually took place. And if they were, the question remains to be answered: What was the basis of this belief?

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SPECIAL CORRESPONDENCE

INTERNATIONAL PHYSIOLOGICAL CONGRESS FUND FELLOWSHIPS

AT the annual meeting of the Federation of American Societies for Experimental Biology in Chicago in 1930, the American Committee for the Thirteenth International Physiological Congress presented to the federation the surplus funds collected for the congress and in accordance with the suggestions of the committee, the International Physiological Congress Fund was established by the federation. The action was as follows:

"The income of the International Physiological Congress Fund shall be used triennially for the appropriation of funds in units of $250 to defray the expenses to international physiological congresses abroad of promising young workers in the field who would not otherwise be able to attend the congress, who shall have creditable papers to read before the congress, whose ages shall be below 35 years, and who shall not yet have attained the rank of full professor. These fellowships are to be allotted by the executive committee of the federation.

"Furthermore, within the judgment of the same executive committee it may be permissible to grant to any candidate an additional sum of $250 provided such candidate desires to spend three months of study in a foreign laboratory. Generally speaking, the executive committee should be guided in the selection of individuals with due regard to the relative numbers of the present membership in the four different societies which constitute the federation. By unanimous vote of the executive committee the rules may be changed at any time governing the amounts of money to be granted to any individual.

"It is furthermore suggested that if and when another international physiological congress shall be held in the United States the principal of this fund shall be turned over to the authorities duly appointed by the officers of the federation to receive it and shall be used for the promotion and support of that international congress."

There will be available for the Fourteenth International Congress to be held in Rome from August 29 to September 3, 1932, four International Physiological Congress Fund Fellowships of $250 each. One fellowship will be awarded in each of the branches of biological science represented by the four constituent societies of the federation: namely, The American Physiological Society, The American Society of Biological Chemists, The American Society for Pharmacology and Experimental Therapeutics, and The American Society for Experimental Pathology.

The conditions for the award of these fellowships, in accordance with the vote of the executive committee of the federation at their Montreal meeting in April, 1931, were fixed as follows:

(1) Each candidate must be recommended as worthy by some member of the society representing the field of study or by some other individual familiar with the character of the candidate's work.

(2) Candidates must be under thirty-five years of age and must not have yet attained the rank of full professor or its equivalent.

(3) Each candidate must present with the application a draft of a meritorious paper to be presented to the congress.

(4) Applications must be made before *January 1, 1932,* to the *secretary* of the society which includes the field of study.

(5) These applications are to be considered by the councils of the respective societies, who shall submit to the executive committee of the federation an approved list of nominees.

(6) Final selection of fellows shall be made by the executive committee of the federation.

It was the consensus of opinion that fellowships should be awarded only to those persons having meritorious work to present to the congress and who would be unable to attend the congress without some financial assistance in the form of a fellowship or other subsidy. It should be noted that membership in the federation is not necessarily a condition for the award of a fellowship.

Applications should be made to the secretary of the society in whose field the work to be presented at the congress lies: for Physiology, Dr. Arno B. Luckhardt, University of Chicago, Chicago, Illinois; for Biological Chemistry, Dr. Howard B. Lewis, University of Michigan Medical School, Ann Arbor, Michigan; for Pharmacology and Experimental Therapeutics, Dr. V. E. Henderson, Medical Building, University of Toronto, Toronto, Canada; for Experimental Pathology, Dr. C. Phillip Miller, Jr., Department of Medicine, University of Chicago, Chicago, Illinois.

HOWARD B. LEWIS, *Secretary*
Federation of American Societies for Experimental Biology

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A SIMPLIFIED INSTRUMENTAL METHOD OF MEASURING SOUND ABSORPTION COEFFICIENTS

SINCE the foundation of the science of architectural acoustics by the late Professor W. S. Sabine,[1] of Harvard, many instrumental methods have been devised to take the place of the ear-reverberation method described by Sabine. Among these instrumental devices are those of Chrisler and Snyder,[2] Wente and Bedell[3] and others.

While most of these instrumental schemes have been quite successful in reducing the measurements to purely objective values, thus eliminating the ear as a source of possible error, yet in most cases the instruments themselves are quite complex and they are not easily assembled from apparatus usually found in physics laboratories. For this reason an effort was made in the present case to devise an apparatus which would be simple, easily assembled and yet reliable.

The usual procedure in instrumental practice as regards sound absorption measurements in reverberation rooms is to make use of the sound decay formula, as developed by Jäger,[4] which, when modified to make it applicable to instrumental methods, is as follows:

$$A_1S_1 = \frac{4\,V \times 2.3 \log_{10}\left(\frac{E_1}{E_2}\right)}{C\,(t_2 - t_1)} \qquad (1)$$

where A_1 is the average coefficient of absorption of the walls, ceiling and floor of the empty reverberation room,

S_1, the area exposed to sound
V, the volume of the room
C, the velocity of sound at the temperature of the room
E_1, a certain sound energy level intensity
E_2, a subsequent sound energy level intensity
t_1, a time in seconds corresponding to E_1
t_2, a time in seconds corresponding to E_2.

When absorbing material is added to the room, equation (1) becomes

$$A_1S_1 + A_2S_2 = \frac{4\,V \times 2.3 \log\left(\frac{E_1}{E_2}\right)}{C\,(t_2 - t_1)} \qquad (2)$$

where A_2 and S_2 are the coefficient of absorption and the area of the material respectively. It is thus obvious that if we have some method of determining E, the sound energy level in the room at any given time, t, it is possible to evaluate A from a curve obtained by plotting values of $\log_{10}E$ against corresponding values of t.

The method being used at Indiana University is essentially as follows:

Sound is produced in a reverberation room by blowing a metal organ pipe of standard make with compressed air at constant pressure as measured by a manometer. After the sound has been maintained for a time, considerably longer than the reverberation time of the room, the air is suddenly cut off and a sound decay curve is made from points determined by the recording apparatus herein described.

The recording apparatus consists of a Jenkins and Adair condenser microphone,[5] the output of which is amplified by a four stage transformer coupled A.C. amplifier as illustrated in the accompanying diagram, Fig. 1. The output of this amplifier is fed through

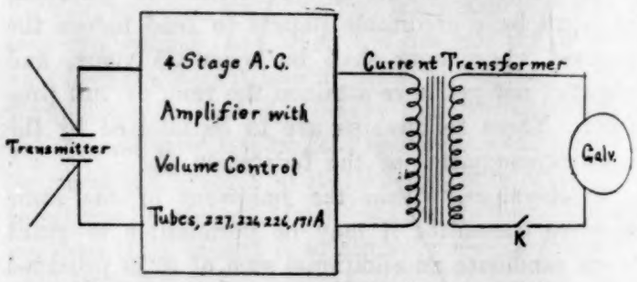

FIG. 1. Diagram of recording apparatus.

a volume control potentiometer into a step-down current transformer from which it passes to a thermo-couple galvanometer,[6] which reads directly in arbitrary energy units. The observer and all the recording apparatus except the microphone is in a room adjoining the reverberation room.

In making a determination of sound absorption, a metronome is set vibrating with a certain period. In coincidence with a given click of the metronome the air is cut off by a valve. At some subsequent click (say the second or third), the key K, is closed, which results in a deflection of the galvanometer. The process is repeated for other settings of the metronome, and of course several readings are taken for each setting, to insure a conservative average. If,

[1] W. S. Sabine, Collected Papers. Harvard Press, 1922.

[2] Chrisler and Snyder, *Bur. Stand. Jour. Research*, Vol. 5, Oct., 1930.

[3] Wente and Bedell, *Jour. Acous. Soc. Amer.*, 1: 422, April, 1930.

[4] C. Jäger, *Wiener Sitz Ber.*, Vol. CXX, 2a, p. 613, 1911.

[5] Note:—An ordinary double button microphone may be substituted for the condenser type thus eliminating special batteries. The outfit then becomes all A.C. and quite portable.

[6] The current transformer and thermo-couple galvanometer are of commercial type and may be secured at nominal cost.

now, the apparatus is calibrated to read in decibels of decay and the output volume control is set accordingly, it is immediately apparent that the values for coefficient of absorption may be calculated from the slope of the curves obtained by plotting values of $\log_{10}E$ against corresponding values of t.

Fig. 2 is a set of curves plotted from data taken as indicated. These curves show the logarithmic

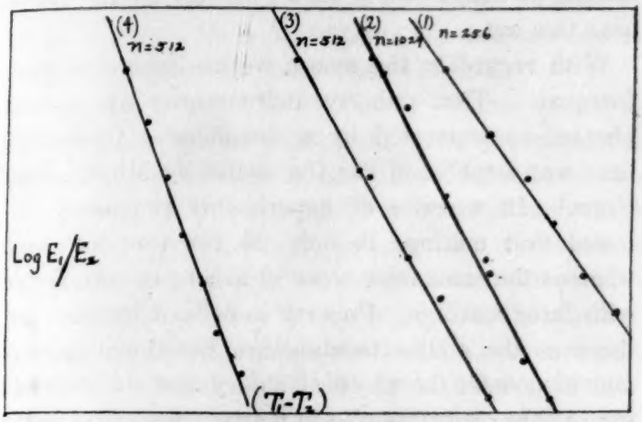

FIG. 2. Decay curves. (1), (2) and (3). Empty room values. (4). Room treated with 30 square feet of material.

nature of the decay quite as well as similar curves obtained by more complicated recording devices. The values for absorption coefficients obtained in this manner have been checked against values for the same kinds of materials found by observers in other laboratories and against values found by the ear method in another room at Indiana University and the agreement is very good.

It will be noted that a coincidence determination is substituted for a duration of time measurement in the older method. It is of course obvious that coincidence determinations are capable of a very high degree of accuracy, a conclusion which is borne out by the fact that the points thus determined fall so nearly exactly on a logarithmic decay curve.

It was intended at first to make an automatic device to cut off the air, and at some subsequent time to close the key, but measurements made in the manner described seem to indicate that little or no improvement would thus be afforded, probably not enough to warrant the added complication.

The apparatus was devised as a means of carrying out a research problem in architectural acoustics which is now in progress under the direction of Professor Arthur L. Foley. The writer wishes to acknowledge his counsel in the matter, and also the many suggestions offered by Professor R. R. Ramsey, of the physics department.

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A NEW DEHYDRATING AGENT FOR HISTOLOGICAL TECHNIQUE

RECOGNIZING the usefulness of a substitute for ethyl alcohol to be used as a dehydrating agent in histological technique, the writer experimented with isopropyl alcohol over a period of 18 months. Isopropyl alcohol, 98 to 99 per cent., may be obtained for about $2.85 per gallon. This percentage may be used directly as absolute alcohol if necessary. It may be made completely absolute by distillation from rock lime.

In the experiments pieces of animal tissues were treated in the usual way (merely substituting isopropyl for ethyl alcohol). Permanent slides made by the paraffin method were set aside for several months and were found to be perfectly good when examined. Later a piece of earthworm which had remained in a paraffin block for a year was sectioned and excellent slides were obtained. In the meantime a class of 38 men with no previous experience in histological technique was given isopropyl alcohol to use. These men made slides of Opalina, changing the grades of alcohol and xylol by pipetting the various solutions from small vials containing the Opalina. They also made whole mounts of trematodes, etc., using either cedar oil or xylol after the alcohol. Finally each man made serial sections of tapeworm proglottids. In every case the technique following the use of isopropyl alcohol was more successful than the technique of previous classes which had used ethyl alcohol.

From the various experiments made, the writer proved that not only is isopropyl alcohol as good a dehydrating agent for animal tissues as ethyl alcohol, but in addition that its use affords important advantages. It does not harden animal tissues as much as ethyl alcohol. Consequently whole mounts of large objects are less likely to break up and tissues imbedded in paraffin seem to section with greater ease. Isopropyl alcohol may be obtained readily by any one since it is not intoxicating. This fact should be of special interest to high-school teachers of biology. The only disadvantage is that it costs more than ethyl alcohol. This is compensated in part by the fact that isopropyl alcohol is less likely to disappear from the laboratory.

I suggest that some one interested in plant histology experiment with isopropyl alcohol to see if it is not superior to ethyl alcohol in respect to the extreme hardening effect of the latter upon certain plant tissues.

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SPECIAL ARTICLES

ON THE RELATIVE STERILITY OF THE ADOLESCENT ORGANISM

THE literature of adolescence is chiefly psychological. Anatomical and physiological studies on the adolescent organism are extremely sporadic and uncorrelated. A recent conference of "experts" served chiefly to emphasize our ignorance of the subject.

One of the prevailing notions concerning adolescence is that it is a very restricted period of time marked by sudden, almost explosive changes in bodily structure and function. The immature organism is represented as becoming all at once mature; the boy becomes a man, the girl a woman, almost as if by a change of clothing. The illusion is probably due to the popular as well as gynecological notion that the first menstruation, which certainly is a definitely demarcated event, is equivalent to the attainment of full maturity. It can, however, easily be shown that puberty and maturity are neither synonymous nor synchronous. The interval of time between the two in man, monkey and rat is about what one would expect with the application of Donaldson's law of equivalent ages: three years, one year and one month, respectively, for man, monkey and rat.

The Carnegie colony of rhesus monkeys has had fifteen females whose every menstrual cycle from the very first was observed. An excellent opportunity was thus afforded for studying the phenomena of adolescence, as affecting body growth, certain changes in the secondary sex characters and changes in the ovaries and genital tract. The sex skin becomes redder and redder and at the same time greatly swollen, almost to pathological proportions at times. Such swellings are extremely rare in mature animals. Furthermore, the menstrual cycles of the young females are extremely irregular in length and duration, and there is a very low incidence of ovulatory as compared with non-ovulatory cycles.

Now, these fifteen females averaged 3,350 grams in weight at the first menses. Most of them were mated soon after puberty, but not a single female conceived before attaining a weight of 4,370 grams. The average weight at first conception of nine of these females was 5,000 grams; hence it is apparent that many menstrual cycles passed between the first menses and the first conception, despite frequent matings in the interval. The interval may be estimated at about a year of time.

The same gradual unfolding of maturity holds true for such good breeders as the rat and the mouse. Slonaker's studies on spontaneous activities in the rat[1] show a gradual increase in the peak of the cyclic activity to the maximum which is maintained during the reproductive life of the individual. This "staircase" phenomenon of adolescence indicates a gradual though saltatory increase in the effect of the ovarian hormone. It is very likely that the first cycles of moderately high activity were unaccompanied by ovulation, though I know of no studies on the rat to bear this out.

With regard to the mouse we are somewhat more fortunate. That puberty and maturity are distinct phenomena separated by a considerable interval of time was established for the mouse by Mirskaia and Crew.[2] In a series of experiments pregnancy followed first matings in only 24 per cent. of cases, whereas the same mice were 80 to 90 per cent. fertile with later matings. Puberty is defined by these authors as the ability to elaborate functional gametes and to possess the physical ability and the desire to play the appropriate rôle in mating; maturity, on the other hand, is defined as the stage of maximum fertility ratio and the ability to produce viable offspring and to rear them.

In this definition, ovulation is included as one of the criteria of puberty. To my notion maturity, the end of adolescence, is marked by the first ovulation and the preparation of a receptive uterus capable of carrying the offspring to term; puberty is indicated by the first manifestations of gonadal activity and marks the beginning of adolescence. The threshold for the hormones causing the latter changes (sex color, menstruation, cyclic variations in spontaneous activity, cornification and opening of the vagina, according to various species are much lower than the changes culminating in ovulation and conception.

The onset of menstruation in girls is, of course, a momentous event. Nevertheless, though the mores of a given people may force "effective marriage" upon them at this moment, there is much indication that, by and large, nature herself prevents motherhood supervening during an important series of preparatory years.

The reader will naturally recall the case of India in this connection and the lurid picture of child mothers conjured up by Katherine Mayo in her notorious "Mother India." This propagandist would have us believe: "The Indian girl, in common practise, looks for motherhood nine months after reaching puberty, or anywhere between the ages of 14 and 8. The latter is extreme, though in some sections not exceptional, the former is well above the average."

In characteristic fashion, Mrs. Mayo fails to con-

[1] *Am. Jour. Physiol.*, 1904, on.

[2] Proc. Roy. Soc., Edinburgh, 1930.

tinue her quotation from the Appendix VII of the 1921 Indian Census, where we read that, though cohabitation begins with puberty, "in the majority of cases the first child is born the third year of effective marriage." Alden Clark[3] has pointed out, furthermore, that returns from maternity hospitals place the first parturition at 18.3 to 19.4 years. At the Madras Maternity Hospital only 10 out of 3,000 cases were under 15! Besides, we learn also from the 1921 census that only 399 out of 1,000 girls were married at 15, which would seem to indicate the average age at menarche is over 15 rather than under 13!

Among gynecologists Dr. Henry Vignes seems to be the only one to recognize the principle suggested in this paper. He says in his "Physiologie Gynécologique" (Paris, 1929), p. 55: "The onset of menstruation does not mean the capacity for conception; many girls who are just beginning to menstruate conceive with difficulty. Godin says that the age of maturity (nubilité), when the individual is capable of reproducing, is about five years after puberty." Dr. Vignes, moreover, kindly sent me a copy of the article "Nubilité" by Mondière in "Le Dictionnaire des Sciences Anthropologiques" (1890?). This gynecologist spent some years in Cochin-China, where he gathered certain data (first menses, first parturition, number of children, menopause, etc.) concerning 960 Annamite, 106 Chinese and 87 Cambodian women. He found that the first menstruation took place on the average at 16¼ years in the Annamites, at 16½ in the Chinese, at 16 10/12 in the Cambodians; the first parturition in these groups at 20½, 16 10/12 and 22½ years, respectively, despite their early marriages. He therefore concludes: "Maturity (nubilité) is often confused with puberty, which is a very different thing, for maturity signifies the faculty of normal reproduction."

This interval between the appearance of the first manifestations of sexual activity and the ability to conceive doubtless explains the Trobiand Islanders' ignorance and denial of physiological paternity and the corollary thereof, a matriarchal form of society, as set forth by Malinowsky in his "Sexual Life of Savages" (London and New York, 1929). Contact with white man has not yet made any headway in convincing the natives that sexual intercourse has any relation to procreation.

Malinowsky is, nevertheless, well-nigh baffled by the fact that despite the absolutely unrestrained and promiscuous sex life of the young Trobiander from childhood on, pregnancy among young unmarried girls is extremely rare—perhaps one per cent. "Can there be any physiological law," the author asks, "which makes conception less likely when women begin their sexual life young, lead it indefatigably, and mix their lovers freely?"

It seems highly reasonable that Malinowsky's predicament is explained by the facts presented in this paper, namely, that the first menstruation (*puberty*) marks merely an early manifestation of a train of events (*adolescence*) which only after three or four years on the average lead to ovulation and conception, the proof of *maturity*.

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[3] *Atlantic Monthly*, February, 1928.

THE ETIOLOGY OF EPIZOOTIC ENCEPHALOMYELITIS OF HORSES IN THE SAN JOAQUIN VALLEY, 1930[1]

EARLY in July, 1930, scattered cases of a peculiar disease of horses which involved the central nervous system began to attract the attention of the livestock owners in certain parts of the San Joaquin Valley. A gradually increasing number of cases was reported from most sections of this region throughout the month of August. With the onset of cool nights the disease disappeared. The peak of the epizootic was reached in the middle of September; no cases were reported after November. From the records of the tallow works and incomplete survey studies it has been estimated that a total of approximately 3,000 horses and mules succumbed to the malady or were sacrificed on account of its sequelae. Close to 6,000 equine animals developed recognizable symptoms. About 50 per cent. of these cases terminated fatally. On one ranch with 687 horses and mules 67 contracted encephalomyelitis and 32 died.

At first the malady was quite generally diagnosed by veterinary practitioners as equine botulism but the spread of the epizootic suggested an infectious disease with an incubation time of from 1 to 2 weeks. Observations revealed febrile reactions preceding the onset of the symptoms which were manifest in form of psychic and motoric disturbances. Signs of fatigue, somnolence, and occasionally excitability, were followed by incoordinated action of the limbs, disturbed equilibriums, grinding of the teeth, paresis and paralyses which varied and were largely dependent on the lesions produced in the innervation centers of the nerves in the brain and the spinal cord. Inability to swallow, paralysis of the lips and bladder, amaurosis, etc., were quite common. In the mild cases which were able to rise recovery was as a rule uneventful and without demonstrable sequelae, but about half were so severe that they terminated fatally in 3 to 8 days or became so obviously hopeless on ac-

[1] From the George Williams Hooper Foundation and the Division of Veterinary Science, College of Agriculture, University of California, San Francisco and Berkeley, California.

count of the complications in form of decubitus, pneumonia, etc., that they were destroyed for humane reasons.

Aside from a slight general icterus and moderately succulent lymph-nodes, and parenchymatous changes in the liver and kidneys no gross anatomical lesions were found at autopsy. The spleen was not enlarged. As a rule the spinal fluid was slightly increased and showed 12 to 30 cells per cmm, mostly lymphocytes and a few leucocytes. The brain and cord were moist and injected.

The most obvious and striking microscopic changes in the brain consisted of hemorrhages around the vessels of the olfactory bulb, brain-stem, medulla and cord. Infiltration of the perivascular sheaths and spaces due to mononuclear and polymorphonuclear cells was variable in intensity. "Cuffing" of the veins and arteries was definite in the advanced cases of the disease. Scattered patches of infiltration in the gray and occasionally in the white matter were common. The distribution of the inflammatory foci differs from that commonly seen in typical Borna disease. Nuclear inclusions of the character described as typical of Borna disease by Joest and Degen were absent. Infiltrations in the lumbar plexus, semilunar and other peripheral ganglia suggest a wide distribution of the virus.

Blood cultures prepared from 10 horses were sterile while the spinal fluid of 11 horses sacrificed or dead on account of encephalomyelitis gave cultures of haemolytic and non-haemolytic streptococci. Certain sections of the brain of a few horses (4 out of 10) contained the same organisms in small numbers. They were non-pathogenic for rabbits and horses on subdural and intravenous inoculation. They were considered secondary invaders without etiologic significance.

Attempts were made to transmit the infection to rabbits by subdural and intracerebral injection of 20 per cent. brain and cord suspensions. The animals failed to manifest definite symptoms. Although moderate febrile reactions of short duration were recorded, the rabbits recovered promptly. Suspensions of the central nervous system of 8 equines sacrificed at different stages of the disease were tested on horses by intra-ocular, intranasal and intracerebral injections and feeding. The brain material from a case in the early stages of the infection produced on intra-ocular injection a fatal malady which was clinically indistinguishable from the San Joaquin Valley disease. Successive passages through horses, monkeys, rabbits, guinea-pigs, rats and mice and reverse transmissions from these animals have as a rule been successful. Clinically as well as anatomically the experimental disease is an acute virus infection identical with the spontaneous equine encephalomyelitis. The infective agent has thus far been demonstrated in the central nervous system by experimental inoculation from two field cases (horses No. 10 and 13). The failures in seven other attempts may be due to the selection of non-susceptible experimental animals, uneven distribution or absence of the virus in the central nervous system of the cases of prolonged duration (autosterilization) or unsuitable administration of the material. For example, the brain suspension of an acute case of encephalomyelitis tested on rabbits, horses and a monkey only produced a mild disease in the latter animal. The serum of this recovered monkey continues to neutralize the virus of horse No. 10.

Recent experiments indicate that the guinea-pig is regularly susceptible for the horse virus and the most suitable animal for an extended study of the disease and its causative agent. In these rodents the disease manifests itself in the form of a febrile reaction, flabbiness of the abdomen, hunched cat pose, salivation, tremors, trotting motions and death in from 4 to 6 days following the intracerebral injection of brain suspensions or filtrates. Not only intracerebral but intranasal instillations of brain emulsions have successfully transmitted the virus to guinea-pigs and rabbits, but not to horses.

The virus survived in one experiment preservation at 4° C. in 50 per cent. neutral glycerine for 12, 21 and 31, but not 105 days, when tested on horses and guinea-pigs. It is filterable through Berkefeld V and N candles and retains its activity in a dilution of 1:1000 although the incubation time may be slightly prolonged.

The nature of the immunity of the horse is unknown. Sera of spontaneously recovered or resistant horses fail to neutralize the virus while the sera of recovered rabbits, guinea-pigs and monkeys may contain antiviral substances.

K. F. MEYER
C. M. HARING
B. HOWITT

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